MISR Level 2 Top-of-Atmosphere/Cloud Products Quality Statement
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Quality Designator:

- **Stage 2 Validated:** Stereo Heights, Stereoscopic Cloud Mask (SDCM) over ocean, Angular Signature Cloud Mask (ASCM) over ocean (including sea-ice)
- **Stage 1 Validated:** Winds, SDCM over land, ASCM over land (including snow and ice), Local, Restrictive and Expansive Albedos (except at high latitudes), Scene Classifiers
- **Provisional:** Broadband Albedos, SVM Scene Classifiers
- **Beta:** Consensus Cloud Classifiers, SVM Cirrus Fraction

MISR maturity level definitions

This statement applies to MISR Level 2 TC Stereo(F07_0013), Classifiers (F04_0006), and Albedo (F04_0007) and beyond until further improvements to MISR software are made. Quality statements covering earlier time periods may be accessed through links at the bottom of this page.

The evaluation of the product quality is on-going. Please read the summary words of caution if you have not done so already.

Many of the algorithms used in the product retrievals have been developed specifically for the MISR instrument, and as such, are relatively untested. Trade-offs with the stereo-matching algorithms have been made at times to sacrifice accuracy or coverage for speed.

In spite of all the warnings, the MISR Level 2 TC Stereo, Albedo and Classifiers software which generated these products is believed to be functioning well except where noted below. This statement highlights major known problems with the products, as well as functionalities which are currently not implemented.

Stereo | Classifiers | Albedo

L2TC Stereo (a.k.a. TC_STEREO) (from MISR PGE8a)

The Stereo Heights are now Stage 2 validated following improvements in the Wind Quality Assessment flags and a study of the stereo heights over ARM sites. The Reflecting Level Reference Altitude (RLRA) is also at this level. This label applies to all products with a version number of F07_0011 or greater. This version of the software went into production on Feb 4, 2004.

The Stereoscopically Derived Cloud Mask (SDCM) for all scene types and Cloud Motion Vectors (winds) are Stage 1 Validated for version F07_0011 of the products.

Several factors affect the quality of the stereo heights including the nature of the scene being matched, the co-registration of the different cameras in Level 1, and the accuracy of the wind retrievals.

OVERVIEW

The MISR cloud-top height retrieval is conceptually simple. An object located above the surface (such as a cloud) will appear in two different positions when viewed from different angles. The apparent change in position (parallax or disparity) as measured by pattern- matching software can be used to calculate the cloud height. The cloud motion vectors (winds) are retrieved first using three angles, then the heights are calculated using the disparity measured between two cameras and the knowledge of the winds.

The winds are calculated at 70.4km resolution and are assumed to be constant over the region. Changes in the estimated wind vectors across the domain boundaries lead to a blocky appearance in the heights at the same resolution. The Stereo Heights and Stereoscopically Derived Cloud Mask (SDCM) are calculated at 1.1 km resolution.

The SDCM is directly derived from the corresponding cloud height. If the stereo height is more than 560 m (the resolution of the stereo heights) above the terrain, the pixel is designated as cloudy. The SDCM is unable to detect clouds over land that are below this altitude.

ERRORS IN VERSION F08_0014 OF TC_STEREO DATA

A software error was discovered for Version F08_0014 of the TC_STEREO data that results in some missing values for the Winds, BestWind Heights, and BestWind SDCM. About 40% of the orbits showed some missing data, and 5% had more than half of their data missing. The data that is present in the file is accurate. The beginning of the orbit is fine, then either the LowWinds or the HighWinds drop out (along with the corresponding heights and cloud masks) at a certain point in the orbit. The WithoutWinds Heights, associated cloud masks and the RLRA are not affected.

The missing BestWind heights also affect the Feature-Referenced RCCM (FRRCCM), the Feature-Referenced ASCM and the CloudFractions. The Albedo product is minimally affected - the BRF's as registered to the top and sides of the RLRA columns are unchanged, but there may be some small differences in the albedo values themselves due to different modelling co-efficients being applied.

CLOUD-TOP HEIGHT CATEGORIZATION

With the addition of the WindQA flags to the product, the StereoHeights and all related fields are now produced in three different types - BestWinds, WithoutWinds and RawWinds.

The BestWinds parameters are only computed for those domains where there was a successful wind retrieval of Good or VeryGood quality. They are set to NoRetrieval otherwise. These data comprise our best guess of what the true stereo height is for each pixel. There is still some blockiness present but it is greatly diminished from previous versions of the data. The WithoutWinds data are calculated assuming a constant value of zero wind everywhere. Over clear or motionless areas, the WithoutWinds will equal the actual stereo height, everywhere else they instead yield a "relative height". The blockiness due to wind discontinuity is removed and the relative variation in the heights over small areas is correct.

The RawWinds product uses all available wind retrievals regardless of their quality with a default to zero wind when no wind measurement is available. This is the algorithm used in previous versions of the stereo product. These heights are blocky due to discontinuities and drop-outs in the wind vectors. This is intended as a diagnostic field to allow assessment of the cloud-top height improvement due to the inclusion of the WindQA flags.

EXPECTED ACCURACY

Under good matching conditions with perfect registration (see Registration paragraph below), the winds are consistent with the theoretical limit of 3 m/s with a corresponding height error of 400 m. Difficulties in applying the stereo-matchers to multi-layer or low-contrast scenes limit the accuracy of the winds and heights. The stereo heights themselves are quantized in units of 560 m. The stereo-matchers lack subpixel accuracy and a single pixel of disparity difference translates into 560 m of height. In general, the stereo-matchers are accurate to within one pixel.

WIND VALIDATION RESULTS

The wind retrieval algorithm has undergone major revisions, both in the calculation of the wind vectors themselves and the determination of their associated quality flags. A new "sub-pixel" wind algorithm has been implemented to calculate the wind vectors from the parallax measurements returned by the stereo matchers. Additionally, a new quality measure based on the difference between the winds calculated using the fwd and aft sets of cameras (An-Bf-Df and An-Ba-Da) is included. The coverage of the good quality winds has been reduced by roughly half, but we now have greater confidence in the wind quality flags.

The Goddard Global Modeling and Assimilation Office (GMAO) has performed a detailed analysis of 6 weeks worth of wind data (Sept 1 to Oct 15, 2003) by comparing it to the expected streamlines derived from 6 hour forecasts. Several thousand observations per day were included in this study. The results are tabulated in the wind errors table.

Quality flags for each individual wind vector are included in the TC product. These flags are computed by looking at the signal strength returned from the stereo-matchers and also at the difference between the winds derived from the forward and aft viewing cameras. The flags are set conservatively so it is possible for "good" winds to be labelled as bad, but very few poor quality winds should pass the quality test. An individual wind-vector should only be considered of Validated quality if both Orbit_QA flags indicate "good", the mean misregistration retrievals for the Df and Da cameras (over the entire swath) is zero, and the individual wind-qa flag indicates "good" or "very good". These misregistration retrievals may be cloud-contaminated, so one should look for a modal peak located at +/- one pixel error.

HEIGHT VALIDATION RESULTS

Comparisons between ground-based millimeter-wave cloud radar and lidar measurements of cloud top and MISR stereo-derived cloud top heights have been conducted using data from 3 sites. One site is in the Southern Great Plains (Lamont, Oklahoma), the second in the tropical western Pacific (Nauru Island), and the third at the North Slope of Alaska (Barrow). These radars and lidars are operated as part of the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) program.

The MISR height retrieval is performing largely as expected when the clouds are thick enough to be identified by the pattern matchers. A summary of results is presented in the height errors table.

For moderately optically thick clouds (5 > tau > 0.5), which may lack well-defined contrast at the cloud top, the MISR retrievals tend to identify structures within the cloud (typically 500m to 1.5km deep) or different cloud layers lower in the atmosphere. Much of the mean offset shown in these summary statistics result from these moderately thick clouds. This optical depth assessment is based on a variety of retrievals using ground based radar and lidar techniques.

The pattern-matchers used in the stereo height retrievals identify the location of greatest contrast, which is not necessarily the highest point in the cloud. MISR, along with many other instruments, has difficulty in retrieving the height of optically thin clouds. The optical depth threshold at which the algorithm identifies the thin cloud rather than the underlying object depends on the contrast of the underlying feature. The reader should take this inherent limitation of the retrievals into account when comparing MISR heights to other instruments or to model results.

For the extreme case of very dark features (such as open water) near bright features such as snow, clouds with optical depth of at least 2 and perhaps as much as 5 can be missed. When boundary layer clouds such as stratocumulus or trade cumulus are present, cirrus clouds with optical depths of 2 to 5 are sometimes not retrieved. However, for cases without lower clouds or underlying bright surfaces, thin cirrus clouds with optical depths near 0.5 (over heterogeneous land) and perhaps even smaller (over dark water) are usually detected.

STEROSCOPIC CLOUD MASK VALIDATION

The Stereoscopically Derived Cloud Mask (SDCM) is calculated solely from the Stereo Heights. If the height is more than 560m above the terrain, it is called a cloud. It is therefore difficult to detect low clouds close to this altitude. The possible values of the SDCM have been relabelled to Cloud (Low/High Confidence) and Near Surface (Low/High Confidence). There is no additional information available to determine whether a pixel with a low feature height is clear or not. The best we can say is that it's near to the surface. Additional radiometric data must be used to distinguish low clouds and fog from clear sky.

The SDCM cloud/no-cloud distinction over clear-sky ocean is good. If the SDCM says Cloudy, then the likelihood of this being true is estimated to be above 95%. This ties to the fact that the Preliminary SDCM consistently returns NoRetrieval over clear-sky ocean because there are not any features for the pattern-recognition algorithms to match. Any retrieval of the SDCM (be it Cloud or NearSurface) over ocean is likely to be cloud. The SDCM (due to the 560m resolution of the stereo heights) has been observed to over-detect clouds in broken boundary layers. This is noticeable in areas dominated by trade cumulus.

The SDCM comes in four flavours - Preliminary_SDCM (BestWinds), Preliminary_SDCM (WithoutWinds), SDCM (BestWinds), and SDCM (WithoutWinds). The "BestWinds" varieties are calculated using the corresponding BestWinds stereo heights, and similarly for the WithoutWinds data. The Preliminary masks are calculated using only stereoscopically derived heights, while the "final" versions use RCCM data to fill in the missing stereo heights over clear-sky ocean.

The SDCM has been validated using a combination of visual inspection, field campaigns and other satellite-derived cloud masks. Its accuracy is estimated at more than 90% over ice-free ocean, and greater than 85% over other surface types including snow and ice. The SDCM over land has been promoted to Stage 1 Validated based on these results and given its close derivation from the Stereo Heights which are now Stage 2 Validated.

A study of the cloud mask against ARM data for the Nauru and Manus sites in the tropical western Pacific shows that the SDCM can detect clouds with an optical depth > 0.3 to 0.5.

WIND RETRIEVAL QUALITY AND HEIGHT BLOCKINESS

The accuracy of the cloud motion retrieval is a key component in the cloud-top height calculation. The winds are very sensitive to any misregistration of the oblique angles, and discontinuity in the wind vectors shows up as clearly visible "blockiness" in the stereo heights (most noticeably in the RawWinds version of the heights - see next section). Drop-outs in the wind vectors result in a default wind field of zero being applied and this will also appear as blockiness in the RawWind heights. In addition, failure of the stereo-matchers will also cause poor quality winds on occasion.

REGISTRATION OF LEVEL 1 DATA AND ORBIT QUALITY FLAG

Level 1 now includes an Orbit Quality (Orbit_QA) flag that assesses the registration quality of the orbit based on the Terra orbit attitude and ephemeris data quality indicators. All of the TOA/Cloud products now read in this quality flag. If the flag indicates that the registration quality of the orbit might be poor, all the BestWind height products in the TC_STEREO file are set to NoRetrieval since it is impossible to retrieve good quality winds if the registration is inaccurate. This decision is made on an orbital basis and is flagged in both the Orbit_QA and CloudMotionSource flags.

Additionally, a new Orbit_QA flag that also measures the registration quality of the entire orbit is now available in the product. This new flag is calculated from the distribution of the fwd-aft wind differences (as mentioned in the Wind Validation paragraph above). A value of -1 for either flag means that the registration of the orbit is suspect. In both cases, the CloudMotionSource flags are set to a value of "1" and all the BestWind Height fields are blacked out. Two other important pieces of file metadata include the mean fwd-aft wind difference as calculated over the entire swath ("Mean_fwd_aft_wind_diff"), and the fraction of domains with an acceptably low wind difference ("Fraction_good_fwd_aft_wind_diff"). Ideally the mean difference should be less than 5 m/s and the fraction of good domains should be more than 0.7.

The co-registration of the Df, Da, Bf and Ba cameras has been improved (significantly so in the case of Da) with the current release of the Level 1 software. See the Georectification Page for more details.

The registration accuracy of the Df and Da cameras in both the along and across-track directions is also reported in the product at 70.4 km resolution. These retrievals generally succeed over clear-sky land, and calculate the misregistration of the D cameras in units of 275 m pixels.

There is a known problem with mistakenly calculating a spurious misregistration over cloud-contaminated areas. Thus if one is concerned about individual misregistration retrievals, the oblique views should be checked for cloudiness to ensure that the scene is indeed clear.

MULTI-LAYER SCENES

Multi-layer scenes and those without a great deal of contrast cause problems for the stereo-matching algorithms. The variation in cloud opacity with view angle, in particular, makes the wind retrieval (and therefore accurate height calculation) difficult. In such cases, MISR will match the layer of greatest contrast, rather than the highest heights. High, thin clouds over a lower-level cloud deck are ignored.

OTHER PROBLEMS

The stereo-matchers lack a robust blunder detection algorithm and will therefore retrieve spurious results on occasion. This results in areas of "noise" in the stereo height field. The scene is pre-screened for sufficient contrast and a failure in this test results in a NoRetrieval in the stereo heights, but sometimes low contrast scenes are matched and will result in difficulties applying the stereo matchers correctly.

Sometimes horizontal stripes of NoRetrieval values will appear in the product. See the Exceptions/Anomalies paragraph in the Level 1 Quality Statement for more details.

DATA SOURCE FLAGS

The Orbit_QA, CloudMotionSource, WindQuality and StereoHeightSource flags all contain key information about the source of the TC_STEREO data. Their values are listed below. The Orbit_QA flag is contained in the global file attributes, the others are available as gridded data fields at the appropriate resolution.

Orbit_QA and Orbit_qa_winds:	-9999.0 = NoRetrieval -1.0 = Poor Registration 0.0 = Nominal Registration
CloudMotionSource:	0 = Stereo Not Attempted 1 = Wind Retrieval Failed due to poor Orbit_QA flag 2 = Stereo Attempted and Failed 3 = Stereo Succeeded for Low Cloud only 4 = Stereo Succeeded for High Cloud only 5 = Stereo Succeeded for Low and High Clouds
WindQuality:	0 = NoRetrieval 1 = Bad 2 = Uncertain 3 = Good 4 = VeryGood
StereoHeightSource:	0= NoRetrieval 1 = Stereoscopically Determined height 2 = Surface Override 3 = Default Cloud 4 = MODIS height
Cloud Masks (SDCM):	0 = NoRetrieval 1 = CloudHighConfidence 2 = CloudLowConfidence 3 = NearSurfaceLowConfidence 4 = NearSurfaceHighConfidence
Cloud Masks (RCCM, ASCM):	0 = NoRetrieval 1 = CloudHighConfidence 2 = CloudLowConfidence 3 = ClearLowConfidence 4 = ClearHighConfidence
Consensus Cloud Classifier:	0 = NoRetrieval 1 = Overcast 2 = KnownCloud 3 = KnownClear

REFERENCES

A study of the MISR-retrieved winds against GOES data is published in the vol. 28, 2001 issue of Geophysical Research Letters (GRL). Height Comparisons made with MODIS, radar, and computationally intensive stereo matching algorithms are documented in the July 2002 issue of IEEE-TGARS and in the August 2002 issue of GRL. An additional study of the MISR heights and winds is available in the proceedings of the EUMETSAT Users' Conference (Antalya, October 2001) by G. Seiz.

Garay M.J., Mazzoni D., Davies R., and Diner D.J. 2005. The application of support vector machines to analysis of global satellite datasets from MISR. Proceedings of the Fourth Conference on Artifical Intelligence, American Meteorological Society, San Diego, CA 9-13 January 2005.

Horvath A., Davies R., Simultaneous retrieval of cloud motion and height from polar orbiter multi-angle measurements. GRL Vol 28, No. 15. 2915-2918 August 2001.

Moroney C., Davies R., Muller JP, 2002: Operational Retrieval of cloud-top heights using MISR data. IEEE Transactions on geoscience and remote sensing. 40 (7). 1532-1540 JUL 2002.

Marchand R., Ackerman T 2004: An assessment of Multi-angle Imaging Spectroradiometer (MISR) stereo-derived cloud top heights using ground-based millimeter-wavelength cloud radars. 14th International Conference on Clouds and Precipitation. Bologna Italy 19-23 July 2004.

Seiz, G., 2003. Ground and satellite-based multi-view determination of 3D cloud geometry. PhD thesis, Institute of Geodesy and Photogrammetry, ETH Zuerich, Switzerland, 2003. IGP Mitteilungen Nr. 80.

FILE FORMAT UPDATES

The TC_STEREO product underwent extensive revision in November 2002 (version F05_0008 of the product file): most of the 1.1 km and 2.2 km resolution field names have been changed, and they have also been re-ordered to put the most important fields at the top of each grid. Please see the Data Products Specifications document for full details.

EXTERNAL DATA SOURCES

No external data sources such as the MODIS cloud-heights and the DAO/NSIDC snow-ice masks are used in the L2TC Processing. The snow-ice data are instead provided by monthly, static climatological inputs from the TASC Dataset.

ALGORITHM UPDATES

There have been several updates to the algorithms described in the ATBD. First, all the wind-retrieval disparities are slotted into a 2-d histogram and a weighted average around the most-populated value is used to calculate a single estimate of the wind for the domain. Secondly, the winds are now calculated separately for the fwd and aft camera triplets and are only accepted if the fwd-aft wind difference is small enough. If there is no stereoscopically retrieved height available, the StereoHeight and SDCM are set to NoRetrieval except in the case of clear-sky over ocean (as determined by the value of the Radiometric Camera-by-Camera Cloud Mask - RCCM) where the surface height is substituted for the missing stereo height. The RLRA is set to NoRetrieval where there is no stereo height, rather than being filled in with default values.

L2TC Classifiers (a.k.a. TC_CLASSIFIERS) (from MISR PGE8b)

The ASCM is Stage 2 Validated (over ocean), and Stage 1 Validated (over land) for all products with a version number of F04_0006 or greater. Sea-ice and snow cover over land are included in these statements. This version of the software went into production on May 13, 2005. The SVM Scene classifiers are debuting at Provisional level, while the SVM Cirrus Fraction is Beta quality. The consensus cloud classifiers remain at Beta quality.

The overall scene classifiers as computed from the SDCM, PreliminarySDCM, and RCCM are now Stage 2 Validated following the declaration of their parent products as Validated. The RCCM-based angle-by-angle cloud-fractions are of Stage 2 Validated quality over water, and Stage 1 Validated over snow-free land. Similarly, the SDCM-based classifiers are Stage 1 Validated. The ASCM-based altitude-binned scene classifiers are also Stage 2 or Stage 1 Validated depending on the surface type. The altitude-based scene classifiers are all Stage 1 Validated. The Classifiers version which has all the scene classifiers at Validated status is F04_0006. This version went into production on May 13, 2005. All Classifiers data at or above this version have all products at Validated status (with the exception of the SVM classifiers and consensus cloud classifiers.

REFERENCES

The physical basis of the ASCM algorithm is available in "A band- differenced angular signature technique for cirrus cloud detection", Di Girolamo L., and R. Davies, IEEE Trans. GeoSci. Remote Sens., vol 32, 1994. Note that although the ASCM is referred to as a cirrus cloud mask in this paper, it is being used as a general cloud mask.

CLOUD AND TOPOGRAPHIC SHADOW MASKS NOT AVAILABLE

The cloud and topographic shadow masks are currently not part of the Classifiers product.

ANGULAR SIGNATURE CLOUD MASK

The Angular Signature Cloud Mask (ASCM) is calculated by thresholding a single observable, namely the Band-Differenced Angular Signature (BDAS). The thresholds for the ASCM depend on the sun-view geometry, the underlying surface type, and season. The ASCM ocean and land thresholds have been updated and now contain seasonally dependant values. When the current validation is complete, this statement will be updated to present the results.

The ASCM algorithm is only valid when one of the D cameras is viewing forward-scattering (defined by scatt_angle(Dcam) <= 92 degrees).

Therefore the ASCM is not calculated in the equatorial regions due to the scattering angles for both D cameras being out of range.

Global cloud distribution maps made from the ASCM show the expected climatological cloud distributions. Validation via visual inspection, field campaigns and satellite data show that the ASCM has accuracies of better than 90% for ice-free ocean and greater than 85% for other surfaces including snow and ice cover. A detailed validation is underway and the results will be reported in this statement when available.

The visual discontinuities present in previous versions of the ASCM have been removed. The final ASCM is now calculated from the individual terrain-referenced versions masks for the forward and aft viewing camera pairs. This means that the ASCM is now terrain-referenced and is on a different projection from the SDCM. Therefore, doing high-resolution pixel-by-pixel comparisons of the three cloud masks is not recommended unless one fully understands the data and the projection issues.

CONSENSUS CLOUD CLASSIFIERS

A new cloud classifier that takes all three individual cloud masks (RCCM, SDCM and ASCM) into account has been added to the Classifiers product as of November 2004 (version F04_0005). These masks are available at 2.2km and 35.2km resolution and classify scenes into three types: "KnownClear" signifying that no cloud at all was detected in the pixel, "KnownCloud" meaning that some cloud was detected, and "Overcast" meaning that that the scene is entirely clouded over. Additionally the maximum stereo height is computed for all regions classified as Overcast. These data have not been validated yet and are therefore not suitable for scientific use; their quality is Beta. In particular, the coarse consensus classifier is quite crude. A new algorithm is currently being developed.

SUPPORT VECTOR MACHINE SCENE CLASSIFIERS

The SVM scene classifier is being introduced at Provisional level following an extensive statistical (10 million pixels from 4 orbits) and visual (hundreds of scenes) validation. The principal classifier is divided into 5 possible classifications (Clouds, Aerosols, Ice/Snow, Water and Land) with two sub-classifications (Dust and Smoke) that are only relevant when the main classification is Aerosols. If the overall classification is not Aerosol, the Dust and Smoke fields should be ignored. The resolution is 1.1 km.

The overall accuracy of the 5-type classifier was found to be 80.9% compared to human expert labelling. When the results were resampled to a 17.6km resolution, the accuracy increases to 84.9%, indicating that a good portion of the errors are isolated blunders rather than gross misclassifications. On selected scenes, the agreement between two human experts doing the labelling was 93.0% at 1.1 km resolution and 96.3% at 17.6km resolution. These numbers therefore represent an estimate of the maximum performance possible for any scene classifier.

Since the SVM scene classifier makes its decision on the scene type using only the locally available data and does not use any information obtained from either the surrounding area or a priori knowledge, some strange classifications are possible. For example, some pixels in the middle of a large cloud will be labelled as ice/snow. Therefore, users of this data should consider the individual pixel results in the broader context of the overall scene.

The SVM has been tuned to detect as many aerosols as possible since they appear quite infrequently (about 1% of the data), thus leading to many false positives. If aerosols are present, the SVM will detect them about 75% of the time. However, for any given pixel that is labelled as aerosol, there is only a 33% chance that it is actually aerosol. Thin clouds are often mis-classified as aerosols. One will occasionally see a river being classified as aerosols while the surrounding land is labelled clear. This is expected behaviour: the variance in colour and texture is much lower for clear water than for land so the SVM is therefore sensitive to much thinner aerosols over water.

Ice and snow detection also cause particular problems since they also occur relatively infrequently. A pixel that is really covered with ice or snow has a 75% chance of being correctly labelled, but the probability that any given pixel with this label is actually ice or snow is only 54%.

The more popular classes of cloud, water and land all have accuracy rates in excess of 80%, both in terms of missing actual occurences of these surface types, and the rate of false positives. Sunglint does not cause a problem since the SVM classifier uses multiple angles in its calculations and the sunglint is typically limited to one or two angles at a time.

SUPPORT VECTOR MACHINE THIN CIRRUS DETECTION

The SVM cirrus detector is debuting at Beta since it has only been tuned for clear oceanic scenes. Cirrus retrievals are rare over any other scene type and any positive retrievals over these scenes should not be trusted. The results look visually reasonable over clear ocean but no quantitative validation has been done. Preliminary analysis with comparisons to ground-based lidar suggests cirrus with optical depths greater than 0.1 are detected using this technique.

The cirrus clouds are detected at 1.1km resolution using MISR's "C" cameras (60 degree tilting angle) and then reprojected to the An camera at 17.6km pixel resolution using climatological estimates of the cirrus height. It has not been determined how much error is due to deviations of the actual cloud height from the climatological estimates, however an error of 5km in the climatological cirrus height is required to cause the 1.1km pixel in the C camera to be reprojected to the incorrect 17.6km region in the An camera. Given that this is generally half the height of the tropopause, the use of the climatological cirrus heights is not expected to introduce a significant error.

CLOUD CLASSIFIERS FIELDS

Since the algorithm for determining the cloud classifiers is so simple, the quality of these products is directly derived from the incoming data. Therefore, one is urged to pay close attention to the quality statements for the SDCM, RCCM and ASCM. All the classifiers except the altitude-binned ones have the same quality as their parent cloud masks. The "BestWinds" version of the Stereo Heights and related cloud masks are used in the calculations of all these products.

The cloud fractions are currently being incorrectly normalized by the total number of 1.1km pixels in a 17.6km region, rather than the number of 1.1km pixels that contain valid cloud mask data. This error will be corrected in the next release of the software. The problem is most evident at the swath edges and shows itself as strips of lower values along the left and right swath edges. The impact on the 17.6km regions in the center of the swath is much smaller. This can be corrected by counting up the number of cloud mask pixels with valid data in a 17.6km region and using that as the normalization factor rather than 256.

The altitude-binned classifiers remain at Stage 1 Validated because no systematic study has been done to determine how much low cloud is being missed because of the SDCM's inability to properly detect clouds lower than the height resolution, etc. One has to take the limitations of the stereo-height retrievals into account when looking at these classifiers.

The earlier problem with the An-camera RCCM as referenced to the cloud-top heights (FR_RCCM in the Stereo product) being masked out in sunglint areas has been corrected in version F07_0011 of the stereo product. This field and the "Combined Cloud Fractions" and "RCCM_AnByHeight" data are now completely populated.

FILE FORMAT CHANGES

The TC_CLASSIFIERS product has undergone extensive revision: most of the field names have been changed, and they have also been re-ordered to put the most important fields at the top of each grid. Please see the Data Products Specifications document for full details.

L2TC Albedo (a.k.a. TC_ALBEDO) (from MISR PGE8c)

The Top-of-Atmosphere BRFs (and all accompanying parameters such as the top and side BRFs and the number of unobscured pixels), and all three texture indices are Stage 1 Validated. The Local, Restrictive and Expansive Albedos (except over snow and ice) are also Stage 1 Validated. All Albedo data with a version number of F02_0004 (which went operational November 12, 2002) or greater are at this level. This applies to both current and reprocessed data.

Broadband versions of the restrictive and expansive albedos were added to the product in version F04_0007 (in production as of November 28, 2004). Currently they are calculated as a linear combination of the four spectral albedos using constant co-efficients. Given the simplicity of the algorithm and visual verification of the results, they are debuting at Provisional status.

The second and third texture indices (grey-level difference vectors) were not available until version F03_0005 of the product and they are validated as of the current release (F04_0007) when normalization errors were fixed. The local albedos are internally consistent regardless of the modelling method used and compare well with the BRF images, and the restrictive and expansive albedos also pass visual inspection.

The accuracy of the albedos is limited by two factors - radiometric calibration and bidirectional corrections. All information in the Calibration Quality statement applies equally well to the albedos. At high latitudes, notably poleward of 60 degrees, the angular models currently fail due to extreme anistropy. Albedos in these regions are frequently over-estimated.

There is no detectable bias difference between the expansive and restrictive albedos. Regionally, their rms difference is approximately 0.04 to 0.10 depending on solar zenith angle. Based on limited studies to date, the rms uncertainty due to bidirectional modeling ranges from less than 0.01 at low latitudes to 0.03 at high latitudes (cloudy scenes only).

CALIBRATION

The reader is urged to pay close attention to the quality of the radiometric calibration as there have been some recent changes made. See the Radiometric Calibration section of the Level 1 Quality Statements.

CLEAR-SKY DETERMINISTIC MODELLING MISSING

The clear-sky deterministic modelling algorithm as described in the ATBD is not yet implemented. When the scene is determined to be clear (by looking at the SDCM), all the local albedo components are calculated using solid-angle weighting.

FACTORS AFFECTING ALBEDO INTERPRETATION

The local albedo is defined as the unobscured reflection from the 2.2 km RLRA and will therefore often appear to be lower than would be expected. If the local albedos are not summarized statistically but instead are looked at on an individual basis, only the ones that have no obscuration should be used. (This information is available at 2.2 km resolution in the NumUnobscuredTop field. Any number >= 64 indicates that there was no obscuration).

Small fluctuations in the value of the RLRA will directly affect the obscuration and the local albedo. For continuous scenes, a 500 m RLRA difference (due to pixel quantization and other factors) typically results in up to a 10% difference in the local albedo due to obscuration effects. This effect is generally not as noticeable in scenes with naturally discontinuous height fields.

FILE FORMAT CHANGES

The TC_ALBEDO product underwent extensive revision in November 2002, (version F02_0004 of the product file): most of the field names have been changed, and they have also been re-ordered to put the most important fields at the top of each grid. Please see the Data Products Specifications document for full details.

LOCAL ALBEDO MODELLING ALGORITHMS

The Local Albedo calculation is first attempted by Deterministic Modelling (if the scene is homogenous), then Stochastic Modelling and finally solid-angle weighting. No modelling is attempted for clear-sky pixels or where the solar zenith angle is < 25.8 degrees. The weights used in the stochastic modelling are based on pre-launch theoretical simulations and will be updated in 2005 to reflect real measurements.

ALGORITHM UPDATES FROM ATBD REV. D

The algorithm for reprojecting the RLRA field down to the surface ellipsoid was found to be flawed and has been completely replaced with a new backwards-projection algorithm that reprojects the BRF's up to the RLRA.

Also see the

- Statement dated May13, 2005 for MISR Level 2 Top-of-Atmosphere/Cloud Products from May 13, 2005, to November 30, 2005.
- Statement dated November 28, 2004 for MISR Level 2 Top-of-Atmosphere/Cloud Products from November 28, 2004, 2004 to May 12, 2005.
- Statement dated February 13, 2004 for MISR Level 2 Top-of-Atmosphere/Cloud Products from November 30, 2003 to November 27, 2004.
- Statement dated October 20, 2003 for MISR Level 2 Top-of-Atmosphere/Cloud Products from October 20, 2003 to November 30, 2003.
- Statement dated August 13, 2003 for MISR Level 2 Top-of-Atmosphere/Cloud Products from August 13, 2003 to October 19, 2003.
- Statement dated November 12, 2002 for MISR Level 2 Top-of-Atmosphere/Cloud Products from November 12, 2002 to August 12, 2003.
- Statement dated April 15, 2002 for MISR Level 2 Top-of-Atmosphere/Cloud Products from April 15 to November 11, 2002.
- Statement dated December 03, 2001 for MISR Level 2 Top-of-Atmosphere/Cloud Products from December 03 to April 14, 2002.
- Statement dated September 27, 2001 for MISR Level 2 Top-of-Atmosphere/Cloud Products from September 27 to December 03, 2001.
- Statement dated March 30, 2001 for MISR Level 2 Top-of-Atmosphere/Cloud Products from March 30 to September 27, 2001.
- Statement dated February 16, 2001 for MISR Level 2 Top-of-Atmosphere/Cloud Products from February 16 to March 30, 2001.